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Sensory evaluations of oxidized carotenoids and precooked, dehydrated sweet potato flakes were conducted. The objectives of this study were to determine if beta-carotene or any of the oxidized carotenoid fractions extracted from sweet potatoes are the precursors of off-odors and off-flavors in precooked, dehydrated sweet potato flakes and if there is a difference in the odors and flavors of standard and deteriorated precooked, dehydrated sweet potato flakes. The responses of fifteen panel members to the odors and flavors of the samples were recorded on scorecards. For olfactory evaluation a paired test was used; whereas, for gustatory evaluation a triangle test was used.

Results of this study indicate that there is a conclusive difference in the odors of the oxidized carotenoid fractions one, three, and five and good and poor sweet potato flakes. The odor of the second carotenoid fraction was found different from the odors of the good flakes but not from the odor of poor sweet potato flakes. Similarities in odors of the remaining carotenoids and both good and poor sweet potato flakes were found.

Sweet potato flakes canned in air were identified as having off-odors and off-flavors. Whereas the sweet potato flake sample canned in nitrogen was considered more desirable. Good sweet potato flakes and good flakes mixed with oxidized beta-carotene were different from the poor sweet potato flakes in both aroma and flavor. There were, however, similarities in the flavors of poor sweet potato flakes and good flakes mixed with the oxidized non-saponifiable

fraction.

The findings of this investigation indicate that beta-carotene is not the precursor of the off-odor and off-flavor of precooked, dehydrated sweet potato flakes. However, there is an indication that the sensory deterioration could be associated with the carotenoid fraction or the non-saponifiable fraction.

SENSORY EVALUATION AND THE RELATIONSHIP OF CAROTENOIDS TO OFF-ODORS AND OFF-FLAVORS OF DEHYDRATED SWEET POTATO PRODUCTS

by

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CHAPTER I

INTRODUCTION

Within recent years dehydration of foods has become increasingly popular. During World War II dehydration became a necessity not only for the preservation of food commodities but also for convenience, quality, and economy. The processing of foods by dehydration has stimulated research in many areas of nutrition, food science, food technology, and agriculture. One of the major problems in the processing of dehydrated food commodities has been the deterioration of the products in storage at ambient temperatures.

The processing of certain dehydrated foods such as sweet potato flakes, carrot flakes, and Irish potato flakes has been accompanied by an off-odor and off-flavor peculiar to each product. A rapid development of the off-odor and off-flavor in the flakes has been detected during storage. Although the exact cause of these off-odors and off-flavors has not been determined, some researchers have observed a close correlation between the decline of carotenoid concentration and the sensory deterioration of the products. These researchers have concluded that the carotenes are precursors of the off-odors and off-flavors.

Other researchers have shown compounds other than the carotenoids to be involved in the development of off-odors and off-flavors. An off-odor and off-flavor peculiar to each product has been found in spite of the presence of

the same major carotenoids. The present investigation was directed towards determining by means of sensory evaluations whether or not carotenes are the precursor of off-odors and off-flavors in precooked, dehydrated sweet potato flakes.

CHAPTER II

REVIEW OF LITERATURE

Dehydrated Sweet Potato Flakes

Dehydration is the controlled drying, by artificial means, of foods. Within recent years the food industry has utilized the process of dehydration to produce new food products for consumer consumption which attempt to satisfy the needs of preservation, quality, economy, and convenience (1).

One such product that the food technologists have been attempting to produce for market is a precooked, dehydrated sweet potato flake. For a long time concern for the development and utilization of the sweet potato crop has been expressed by growers, shippers, processors, and agricultural researchers. The recognition of the need for a new form of sweet potatoes has long been apparent (2, 3).

Sweet potato flakes were developed at the Southern Utilization Research and Development Division of the United States Department of Agriculture, New Orleans, Louisiana, and commercial production of sweet potato flakes began in 1962. There are now two plants in operation in North Carolina, and the opening of a third plant in Louisiana is anticipated (4).

A major problem in the processing of the sweet potato product, however, has been how to prolong the storage stability of the precooked, dehydrated sweet potato flake at room temperature (5). Food technologists have found that sweet

potato flakes rapidly develop off-aromas and off-flavors during storage unless special precautions are introduced during the processing and/or packaging stages. Several methods for processing dehydrated sweet potatoes have been conducted experimentally. Molaison et al. (6) found that dehydrated sweet potatoes canned under nitrogen, where the atmosphere of oxygen was equal to or less than 2 per cent, had good keeping qualities at 70°F and lacked off-odor and off-flavor after 12 months or after 6 years in storage at ambient temperatures. Deobald et al. (7) found that dehydrated sweet potato flakes packed in nitrogen in sealed cans with an oxygen content of less than 2 per cent of the atmosphere in the sealed container and stored at 70° and 100°F resulted in products of good quality and stability. Deobald et al. (8) found that the beta-carotene content of flakes canned in air decreased steadily. Flakes canned in nitrogen containing 6 per cent oxygen showed a slower but steady loss of beta-carotene, whereas, those packed at the 2 per cent oxygen level remained relatively stable.

Packaging and storing dehydrated sweet potato flakes have remained a problem of great concern to the processors. The new product has been successfully packed in metal containers under a nitrogen atmosphere for an 18 month period without loss of flavor (4).

Other researchers have investigated the effects of time and temperature of storage on dehydrated sweet potatoes (9, 10), and the effects of oxygen on the stability of dehydrated sweet potato flakes (10). Lambou (9) found that dehydrated flakes made from raw sweet potatoes stored at 50°F produced

unpalatable reconstituted products. Dehydrated flakes made from raw sweet potatoes stored at 60° and 70°-75°F produced palatable reconstituted products. Time and temperature of storage of the dehydrated products had little or no effect on the palatability of the reconstituted product. Deobald et al. (10) observed that flakes canned in air at 70° and 100°F were unacceptable after one month's storage and that the beta-carotene values decreased progressively.

Several researchers (7, 8, 10, 11) have suggested that the sensory degradation of dehydrated sweet potato flakes during prolonged storage was correlated with the deterioration or loss of carotene from the product. A similar situation has also been observed in precooked, dehydrated carrot flakes (12, 13).

Purcell (5) reported that only the residue from composite beta-carotene fractions had an odor resembling the characteristic odor of deteriorated sweet potato flakes. However, the odors of pure beta-carotene crystals and of deteriorated sweet potato flakes did not appear to be the same. Purcell concluded that his data did not offer a satisfactory explanation for the origin of the off-aromas and off-flavors of the deteriorated flakes. Results from the research of Purcell (5) indicated that compounds associated with the carotenoids could be the primary sources of the undesirable sensory changes that can occur in precooked, dehydrated sweet potato flakes.

Purcell (5) described the off-odor and off-flavor which developed in the deteriorated sweet potato flakes, as a distinctive hay-like odor. This hay-like odor of the deteriorated flakes differed from the characteristic violet odor of

the beta-carotene crystals. Judges described differently the odor of deteriorated flakes stored at varying temperatures and times. Odors of sweet potato flakes have also been described as stale beany, slightly and strongly rancid, sour, burnt, slightly caramel, and hay-like (9). Falconer et al. (11) described the off-flavor which developed in dehydrated carrot flakes as having a violet-like odor and suggested the odor to be due to the formation of beta-ionone formed by oxidation of beta-carotene.

Sensory Evaluation

Food researchers and technologists have relied upon the senses of smell, taste, sight, and feel in food quality evaluation (14). The availability of few well-established facts regarding techniques and plans for sensory difference tests (15) and individual, not always consistent, human judgment (16) has limited the reliability of data analyzed by these methods (14). Sensory evaluation has been found to be a convenient method of assessing food quality, but, its usefulness has been limited by the lack of an adequate language for expression and for record (17).

Crocker and Sjastrom (18) defined odor as the property of a substance which excites the sense of smell. Olfactory sensitivity was found to vary so greatly among people that differences always detected by some were never detected by others (19, 20).

Flavor has been defined by Crocker (21, 22) as that property of a food or beverage that makes it excite the senses of taste and smell as well as the sense of feeling in the mouth and nose. Smell was found to be the most

important component of flavor (23). Crocker (21) reported the senses of taste and smell to be quite distinct and separate.

The general concept of difference testing should be based upon discrimination rather than judgment (24). A number of experiments have been conducted to compare sensory methods of measuring differences in food qualities. Dawson and Dochterman (25) reported that the triangle test inspired more confidence in results because of the opportunity to eliminate judges who could not identify identical samples. Lockhart (26) concluded that the triangle test provided a better method of assessing differences or discrimination, but that the paired test was more successful in measuring quality judgment and preference. Gridgeman (27) found both paired and triangle tests to be equally successful for the detection of small differences in intensity and quality of two flavors. Peryam and Swartz (24), however, reported that the triangle test gave greater precision in many test instances.

In the triangle test, a standard is used. Critical samples are a trio of unknowns with two identical samples (15, 24, 27, 28, 29, 30). In the paired test, a standard is not presented. There are only two samples per test (15, 27, 30). The paired samples are judged by comparison with each other (14, 15, 28).

Boggs and Hanson (15) have indicated that the factors related to accuracy of tests depends on the experimental plan, judges, and conditions of testing. Characteristics to be evaluated should be limited in the experimental plan. The standard may be fresh material, material processed under the best-known

conditions, or a well-known variety. The number of replications needed was found to depend on variability of the samples, results of the judges, magnitude of difference between samples, and completeness of information desired in one experiment (14, 15, 16, 27).

In studying the effect of the number of judgments in a test on flavor evaluation, Sather and Calvin (31) found that with mild products up to twenty samples were successfully evaluated with no decrease in the ability of the judges to discriminate flavor preferences among samples. Kramer et al. (32) found the optimum number of samples for evaluation at one session was determined by the nature of the substance being tested. Boggs and Hanson (15) observed that the problem of fatigue included the actual tiring of the sense organs and possible mental or psychological fatigue that resulted if too many samples were presented at one time. Laue et al. (33) found that fatigue appeared prominent in tasting some types of food products and was practically negligible in others. Fatigue has been prevented by limiting the number of samples to be tasted at any one trial.

To avoid any "settling down" effect on discrimination, Gridgeman (27) ran two initial dummy sessions. Tasters were not aware that the experiment began on the third session.

Harries (34) reported from a study of positional bias in sensory assessment that the judges tended to choose the central sample of three as the odd one in triangle tests. To eliminate this bias, Harries proposed randomized coding so that in any one taste test, the odd sample would be coded 1, 2, 3 an

approximately equal number of times.

A serious limitation of all objective sensory testing has been variabilities of the responses of individuals to a given stimulus and of the response of one individual at different times (15). Peryam (35) found learning to be an important factor in the responses of individuals.

Health, smoking, psychological factors, and age have been considered possible causes for individual variation in the ability to distinguish differences in food (14, 15, 36). These variations can be reduced by training, selecting, checking performance on tests, and developing good attitudes toward the tests (14, 15, 16, 24, 36). Kramer et al. (32) found that fewer, well-trained tasters with sufficient replicates achieved the desired precision. Lambou (9), in an organoleptic evaluation of dehydrated sweet potatoes, used a taste panel composed of 19 members selected on the basis of their acuity.

The assumptions that one can not taste as well immediately after eating and that physical fatigue decreases efficiency of taste performance have not been substantially correlated. No conclusive evidence has been found concerning subject variability due to time of day or day of week (28, 32, 37, 38).

Although the instructions to the judges can vary from test to test, all instructions should be clear, concise, and appropriate (14, 28). Judges should be informed as to the objectives of the experiment (14).

Testing environment must be conducive to concentration. The room should be free from distractions and interruptions (15, 28, 39). Several investigators (15, 28) recommended the use of air-conditioned rooms to provide

constant temperature, humidity, and an atmosphere free from odors as well as the use of controlled lighting and background. Lambou (9) successfully used red light to mask color differences in sweet potato samples.

Utensils selected for use in tasting should be uniform and should not impart any flavor to the food being evaluated (15). Stainless steel forks were used to taste samples of sweet potatoes in a study conducted by Lambou (9). Several researchers (15, 24, 28, 30, 32, 40) reported that samples should be prepared and served as uniformly as possible. In addition the size of sample, temperature, texture, appearance, and color must be controlled, and the actual identity of the sample should be concealed by coding. Texture differences of sweet potatoes were masked by whipping the reconstituted material with an electric beater in a study of organoleptic evaluation of sweet potatoes (9).

Rinses have been found necessary for removing flavors from the mouth before proceeding with the next sample when tasting. The most universally recommended rinse has been water at room temperature (15).

CHAPTER III

EXPERIMENTAL PROCEDURE

The primary objectives of this study were to determine (a) whether or not aroma from off-flavored sweet potato products could be distinguished from oxidized carotenoids, (b) whether or not aroma from off-flavored sweet potato products could be distinguished from control sweet potato products, (c) if the aroma and flavor of the control sweet potato products mixed with oxidized carotenoids could be differentiated from off-flavored sweet potato products, and (d) if there was a relationship between various oxidized fractions of carotenoids and the off-odor and off-flavor in dehydrated sweet potato products.

Description of Dehydrated Sweet Potato Flakes

Precooked, dehydrated sweet potato flakes of the Goldrush variety were obtained from the Southern Regional Research Laboratory of the United States Department of Agriculture, New Orleans, Louisiana. Two samples of dehydrated sweet potato flakes were used for this experiment, a control and one which was deteriorated. The sweet potato samples which were used as controls and were designated as standard or good were processed by the newer

raw-grind technique[1] and packaged in an atmosphere of nitrogen. The sweet potato samples which were designated as deteriorated or poor were a composite of control samples of several runs prepared by the Southern Regional Laboratory. These poor samples had been packed in an atmosphere of air and stored for approximately one and a half years. The deteriorated samples were mixed for five minutes in a Hobart mixer to obtain a homogeneous mixture. Neither stabilizers nor additives were added to the sweet potato samples used in this study. All flake samples were stored at 0°C when they were received until they were used in this study.

Preparation of Oxidized Carotenoids

Carotenoids were isolated from sweet potatoes by the method of Purcell (41). Raw Goldrush variety sweet potatoes were peeled, pureed, and blended with two volumes of methanol. A Hyflo Super-Cel filter aid was mixed with the puree in a ratio of five grams per 100 grams of plant material. The mixture was filtered by means of a Buchner funnel and dried. The filtrate was discarded. The dried mat was scraped into a beaker and extracted by stirring with 100 milliliters of a 1:1 mixture of acetone and hexane. This mixture was filtered and the resulting filtrate was kept for later steps. Extraction of the residue material with the acetone-hexane mixture was repeated, and a second filtrate was obtained.

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[1]Letter from H. J. Deobald, Head, Rice and Sweet Potato Investigations, Food Crops Laboratory, United States Department of Agriculture, Agriculture Research Service, Southern Utilization Research and Development Division, New Orleans, La. March 27, 1967.

The filtrates were combined in a separatory funnel and allowed to separate into two distinct phases, an epiphase and a bottom phase. The bottom phase was transferred to another separatory funnel and extracted with ether. The ether fraction was combined with the hexane epiphase, and the mixture was washed with water to remove the acetone. The ether-hexane fraction was saponified for thirty minutes with one-fourth volume of saturated methanolic potassium hydroxide. After saponification the lower phase which formed was removed and diluted with water. The diluted lower phase was extracted with ether. Ether was also added to the non-saponifiable extract, and the mixture was washed free of alkali. The carotenoid-hexane mixture was concentrated by means of a rotary-film evaporator.

The pigments of the carotenoid-hexane mixture were separated by means of column chromatography. The column was packed with magnesium oxide (Fischer Seasorb) and Hyflo Super-Cel (1:1 w/w). The column was developed with hexane until phytofluene and phytoene were distinctly separated from beta-carotene. To distinguish this separation a florescent instrument had to be used. After separation of the florescent pigments from beta-carotene, the column was developed with a 5 per cent acetone in hexane solution to separate beta-carotene from zeta-carotene. After separation of the pigments, the column was extruded, and the separate bands were carved out into individual flasks. The pigments were recovered with a 100 milliliter acetone-hexane (1:1) solution.

Spectral curves of the pigments were obtained with a Cary Model 11

Recording Spectrophotometer. Partition coefficients for the isolated pigments were determined by shaking a hexane solution of each fraction with an equal volume of methanol-water (95:5 v/v) saturated with hexane (42).

Each carotene fraction was concentrated in a rotary-film evaporator and saturated with oxygen in order to oxidize the fractions. The oxidized carotenoids were stored in covered vials at room temperature until used.

Oxidized beta-carotene and non-saponifiable fractions were furnished by Purcell[2]. The carotene and the non-saponifiable fraction was dissolved in ether. Sufficient anhydrous starch was mixed with the solution so that two grams of starch mixture would provide 4.3 milligrams of non-saponifiable fraction or 3.9 milligrams beta-carotene per two grams of starch. The solution containing starch was evaporated to dryness with a rotary-film evaporator. The starch coated with pigments was then scraped into the container for storage. The container was placed in a desiccator, and a high vacuum was drawn. The vacuum was released with oxygen, and the container removed and stored until used.

Preliminary Tests

A series of preliminary tests was conducted in order to obtain information concerning sample size and state, environmental conditions, and appropriate tests and scorecards to be used for the evaluation of dehydrated sweet potato

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[2]Letter from A. E. Purcell, Senior Chemist, Food Crops Laboratory, United States Department of Agriculture, Agriculture Research Service, Southern Utilization Research and Development Division, Raleigh, N. C. March 9, 1967.

flakes. Available faculty, staff, and students served as panel members for the preliminary tests.

A paired test was favored by the panel members for odor evaluation. With only two samples in a paired test, there was less confusion of sample odors by the panel members than with three samples in a triangle test. Differences in odors of the samples were more easily detected when samples were presented dry rather than reconstituted. Presenting the samples in a 50 milliliter beaker concentrated the odor in a small area and made it possible to distinguish differences better than when samples were presented in small, shallow aluminum trays.

A triangle test was preferred by the panel members for flavor evaluation. The panel members were able to detect differences in sample flavors when reconstituted samples were presented in 50 milliliter beakers in a triangle test. Knowing that two of the samples were identical in flavor and that one sample was different appeared to increase the ability of the panel members to correctly identify the odd sample. The panel members were able to detect off-flavors in the samples and to identify the off-flavored samples in a triangle test.

When the oxidized carotenoid fractions were first smelled, the panel members detected a strong chemical odor. The chemical odor was compared with the odors of pure solutions of acetone and hexane and found similar. The tops from the vials containing the oxidized carotenoid fractions were removed one week prior to the start of the experiment to allow the chemical odor to escape.

Color differences in the dry and reconstituted samples were readily detectable by the panel members and seemed to influence their judgment. The use of red lighting was successful in masking the color of the samples, thus reducing color bias.

Several scorecards for both the paired test and the triangle test were used during the preliminary test sessions. For odor tests, the scorecard which indicated the relationship of the odors as alike, related, or different was preferred. In the flavor tests more information was needed to determine whether or not off-flavors existed and in which samples these flavors were present. The panel members were asked, therefore, to identify the odd sample, and to state the factor or factors influencing their decision. The panel members were also asked to indicate whether or not off-flavors were present and to identify the sample or samples with off-flavors.

Preparation of Samples

Dry samples of dehydrated sweet potato flakes were used in a paired test for olfactory evaluation. For gustatory evaluation three different samples of dehydrated sweet potato flakes were evaluated. The following reconstituted sweet potato samples were compared with poor flakes: (1) good flakes, (2) good flakes mixed with oxidized beta-carotene, and (3) good flakes mixed with the oxidized non-saponifiable extract of sweet potatoes. For gustatory evaluation dehydrated sweet potato flakes were reconstituted according to the directions given on the label. Upon reconstitution the sweet potato samples were blended for five minutes in an Osterizer to mask texture differences. These wet

samples were prepared daily for the triangle tests.

The beta-carotene and non-saponifiable coated starch fractions were mixed with the good dry flakes prior to evaluation. The pigment coated starch fractions were added to the flakes in the ratio of two grams of pigment fraction per ounce of flakes. The amount of flakes needed for evaluation each day was weighed and reconstituted.

Both dry and reconstituted samples were presented in 50 milliliter beakers. The oxidized carotenoids were presented in small glass vials. The outsides of both the beakers and vials were covered with red construction paper to reduce color bias. All sweet potato samples for both olfactory and gustatory evaluation were coded by the use of capital letters. The oxidized carotenoid fractions were coded by small letters. All letters were drawn randomly from a box and assigned to the samples in the order in which drawn.

Design of the Experiment

Evaluation sessions were held for six weeks during February and March in the home economics building. Panel members were scheduled to evaluate daily at one of the following times: 9:30 to 10:00 A.M., 10:00 to 10:30 A.M., 10:30 to 11:00 A.M., and 2:00 to 2:30 P.M. Either three, four, or five panel members were present at each time session.

At each session individual trays containing the samples and the score-card were set up for each test. The number of tests per session varied with the type of test used. For olfactory evaluation a range of seven to ten tests were judged at each session. For gustatory evaluation three tests were judged

per session. Panel members were seated at desks which faced the walls of the room. One test at a time was placed before the panel member. The panel member evaluated the test and placed the completed scorecard face down on the tray under a piece of construction paper. The completed test tray was removed and another test tray placed before the judge until all the tests for each session had been evaluated. Although no time limit was set for judging each test, the panel members were asked not to smell or taste any one sample more than once. Panel members were asked not to talk during the evaluation session and not to make any unnecessary facial expressions while judging the samples. The sequence of tests was randomized by the drawing of numbers from a box. The order of the samples used was changed at each session to eliminate positional bias.

The experiment was divided into odor tests and taste tests. Two methods of difference testing were utilized, paired tests and triangle tests. A paired test was used for olfactory evaluation. In the paired test two different coded samples were presented. Standard and poor dry samples were compared with one another and with oxidized carotenoids. The panel members were asked if the aroma of the two samples was alike, related, or different (See Scorecard, Appendix I). When sweet potato flakes were compared with oxidized carotenoids, the panel members were asked to smell the sweet potato sample first to reduce fatigue, because oxidized carotenoids appeared to be more concentrated in odor. During the preliminary study the panel members had reported that they were able to distinguish a difference between the odors of the sweet potato and oxidized

carotenoid fractions better if they smelled the sweet potato sample first. In the paired tests of dry sweet potato flakes and oxidized carotenoids, eight paired samples were presented at each session and five replications were made. The number of samples to be presented at each session was determined from information gathered during the preliminary testing. The panel members did not experience fatigue as readily when the paired test was used with a larger number of tests as when the triangle test was used.

After comparing good and poor sweet potato flakes with oxidized carotenoids, paired tests of good and poor dehydrated sweet potato flakes were conducted. The panel members were asked if there was a difference in the odor of the two samples. If the panel members detected a difference in odors of the two samples, they were asked to indicate which sample was more desirable (See Scorecard, Appendix I). Five replications of good and poor sweet potato tests were made.

Triangle tests were utilized for gustatory evaluation. Three coded samples of hydrated sweet potato flakes were presented to the panel members. The panel members were asked to select the odd sample and to indicate the factor or factors of aroma, flavor, or aroma and flavor which influenced their judgment. The panel members were also asked whether or not there were any off-flavored samples and to identify the off-flavored sample or samples if present (See Scorecard, Appendix I). Poor reconstituted sweet potato samples were compared with good samples, good samples mixed with oxidized beta-carotene, and good samples mixed with the oxidized non-saponifiable fraction. One test of

each of the three comparisons was evaluated daily and five replications were made.

Following gustatory evaluations another series of olfactory tests was conducted. Results from the first test needed clarification, because many judgments indicated samples were related. Four of the tests of sweet potato flakes and oxidized carotenoids were eliminated because a majority of the judgments from previous testing indicated the samples were different in odor. Procedures for this experiment were the same as those utilized in the first phase of olfactory evaluation. In the paired test of dry sweet potato flakes and oxidized carotenoids, ten paired samples were presented at each session and three replications were made. The panel members were asked to indicate whether the odors of the two samples were alike or different (See Scorecard, Appendix I).

Selection and Training of the Panel

The fifteen people who served as members of the panel in this study were seniors, graduate students, or faculty and staff who were available and willing to participate at the time of the study. All but one were associated professionally with home economics.

The group of panel members was composed of women. A questionnaire (Appendix I) revealed that the age range of the panel members was between 21 and 50 years. There were eleven panel members who were non-smokers, two panel members who were smokers and two panel members who smoked occasionally or very little. The questionnaire further revealed that five panel

members liked sweet potatoes exceedingly well and nine panel members liked sweet potatoes moderately well. None of the panel members disliked sweet potatoes; however, one panel member liked sweet potatoes only fairly well. Of the fifteen panel members, eleven people had had some previous sensory evaluation test panel experience while the other four panel members had had no previous test panel experience.

Training periods were held for each group of panel members the first two days they met. At the first session the panel members were given information concerning the study. The methods of difference testing to be used, the paired test and the triangle test, were explained. Instructions for the use of the scorecards were given to the panel members. An information sheet explaining procedures to be used for smelling and tasting the samples was also presented to the panel members (Appendix I). During the training sessions the panel members were given the opportunity to practice proper techniques of olfactory evaluation. Actual gathering of the data began at the third session.

Throughout the experiment the panel members were asked to make comments on the backs of the scorecards concerning evaluation of the samples. These comments were used in evaluating the results.

CHAPTER IV

RESULTS AND DISCUSSION

Detailed data gathered during the odor detection of oxidized carotenoids and good and poor sweet potato flakes are presented in Appendix II, Tables 1-4.

Paired and triangle tests were given to fifteen panel members to determine if there is a relationship between various oxidized fractions of carotenoids extracted from sweet potatoes and the off-odor and off-flavor which develops in precooked, dehydrated sweet potato products after storage. The ability of panel members to distinguish aroma of good sweet potato flakes from oxidized carotenoids in paired tests for five replications is presented in Table 1. A marked difference in odors was indicated in only three of the eleven fractions of oxidized carotenoids compared with the good sample. Carotene fractions one, two, and five were judged different in odor in 80 to 98 per cent of the total judgments made. The odor of the supernatant of the oxidized carotene three, or beta-carotene, was judged different in odor from good sweet potato flakes by 78 per cent of the total judgments made; whereas, only 48 per cent of the judgments made for pure crystals of beta-carotene and good sweet potato flakes was judged different. The odors of the oxidized carotenoid fractions four and six were evaluated as different in slightly more than 50 per cent of the judgments and related in more than 25 per cent of the judgments. Panel members indicated that

TABLE 1

ABILITY OF PANEL MEMBERS TO DISTINGUISH AROMA OF GOOD SWEET POTATO FLAKES FROM OXIDIZED CAROTENOIDS[a]

Position Number	Designated oxidized carotenoids	Per cent of Responses[b]		
		Alike	Related	Different
1	phytoene	0	1.33	98.67
2	phytofluene	4.00	16.00	80.00
3	beta-carotene (pure crystals)	13.33	38.67	48.00
3	beta-carotene (supernatant)	6.67	14.67	78.67
4	zeta-carotene	18.67	28.00	53.33
5	mono-5, 8 beta-carotene epoxide	6.67	13.33	80.00
6	"pro-gamma"	13.33	33.33	53.33
7	gamma-carotene	18.67	36.00	45.33
8	di-5, 8 carotene epoxide	20.00	42.67	37.33
9	cis-5, 8 cryptoxanthin	29.33	38.67	32.00
10	cis-5, 8 epoxide	32.42[c]	36.49[c]	31.08[c]
11	5, 8 cryptoxanthin	29.33	40.00	30.67

[a]Per cent of panel members making judgments on paired tests.

[b]Based on 75 judgments unless otherwise indicated.

[c]Based on 74 judgments.

the odors of the oxidized carotenoids eight through eleven were related in odor to the good sweet potato flake samples. Of the total number of judgements, 30 to 45 per cent were different and 36 to 42 per cent of the total judgments were related. None of the odors of the oxidized carotenoid fractions was evaluated markedly like the good sweet potato flakes in aroma.

Olfactory evaluation of poor sweet potato flakes and oxidized carotenoids in paired tests is shown in Table 2. A difference in the odor of the poor sweet potato flake sample and the first oxidized carotene fraction was indicated by 90 per cent of the responses. The odor of the second oxidized carotene was judged different from the odor of poor sweet potato flakes by only 44 per cent of the responses. The panel members did not detect a difference in the odors of carotene two and poor sweet potato flakes as readily as the difference was detected in the odors of carotene two and good sweet potato flakes. The odor of the pure crystals of beta-carotene was judged different in odor from poor sweet potato flakes by 60 per cent of the total judgments made; whereas, only 44 per cent of the judgments made of the supernatant of beta-carotene and poor sweet potato flakes was judged different. More difference in the odors was detected when poor sweet potato flakes were compared with pure crystals of beta-carotene than when good sweet potato flakes were compared with pure crystals of beta-carotene. In contrast, the panel members detected more difference in the odors of the supernatant of beta-carotene and good sweet potato flakes than poor sweet potato flakes. The odors of the carotenoid fractions five, six, and nine were evaluated different in 50 to 56 per cent of the total responses and related

TABLE 2

ABILITY OF PANEL MEMBERS TO DISTINGUISH AROMA OF POOR SWEET POTATO FLAKES FROM OXIDIZED CAROTENOIDS[a]

Position Number	Designated oxidized carotenoids	Per cent of Responses[b]		
		Alike	Related	Different
1	phytoene	1.33	8.00	90.67
2	phytofluene	29.33	26.67	44.00
3	beta-carotene (pure crystals)	6.67	33.33	60.00
3	beta-carotene (supernatant)	26.67	29.33	44.00
4	zeta-carotene	20.00	36.00	44.00
5	mono-5, 8 beta-carotene epoxide	24.00	20.00	56.00
6	"pro-gamma"	10.67	34.67	54.67
7	gamma-carotene	21.33	41.33	37.33
8	di-5, 8 carotene epoxide	18.67	40.00	41.33
9	cis-5, 8 cryptoxanthin	16.00	33.33	50.67
10	cis-5, 8 epoxide	18.92[c]	43.24[c]	37.84[c]
11	5, 8 cryptoxanthin	18.92[c]	44.59[c]	36.49[c]

[a]Per cent of panel members making judgments on paired tests.

[b]Based on 75 judgments unless otherwise indicated.

[c]Based on 74 judgments.

in 20 to 34 per cent of the responses. The panel members did not detect a difference in the odors of carotene fraction five and poor sweet potato flakes as readily as a difference was detected in the odors of carotene five and good sweet potato flakes. Odors of the oxidized carotenoid fractions four and eight were evaluated different in 40 per cent of the total judgments; whereas, the odors of the oxidized carotenes seven, ten, and eleven were evaluated different from poor sweet potato flakes in 36 per cent or more of the total responses. Panel members indicated that the odors of oxidized carotenoid fractions seven, eight, ten, and eleven were related in 40 per cent or more of the total responses indicating similarities of the odors of these fractions and poor sweet potato flakes.

The results of a second series of paired tests for odor detection in good sweet potato flakes and oxidized carotenoids are presented in Table 3. Differences in the odor of beta-carotene for both the pure crystals and the supernatant and the odor of good sweet potato flakes were found. A difference in the odors of the oxidized carotenoid fraction nine and good sweet potato flakes was detected in more than 70 per cent of the responses. The odors of the oxidized carotenoid fractions six and eleven were found different from the odor of good sweet potato flakes in 64 per cent of the total judgments. Oxidized carotenoid fractions four, seven, and eight and good sweet potato flakes differed in odors in more than 50 per cent of the total responses. The oxidized carotenoid fraction ten was the only sample which was judged like good sweet potato flakes by over 50 per cent of the responses.

The results of a second series of paired tests for odor detection in poor

TABLE 3

ABILITY OF PANEL MEMBERS TO DISTINGUISH AROMA OF GOOD SWEET POTATO FLAKES FROM OXIDIZED CAROTENOIDS[a]

Position Number	Designated oxidized carotenoids	Per cent of Responses[b]	
		Alike	Different
3	beta-carotene (pure crystals)	15.56	84.44
3	beta-carotene (supernatant)	11.11	88.89
4	zeta-carotene	42.22	57.78
6	"pro-gamma"	35.56	64.44
7	gamma-carotene	48.89	51.11
8	di-5, 8 carotene epoxide	42.22	57.78
9	cis-5, 8 cryptoxanthin	28.89	71.11
10	cis-5, 8 epoxide	53.33	46.67
11	5, 8 cryptoxanthin	35.56	64.44

[a]Per cent of panel members making judgments on paired tests.

[b]Based on 45 judgments.

sweet potato flakes and oxidized carotenoids are shown in Table 4. Significant differences in the odor of both the pure crystals and the supernatant samples of beta-carotene and the odor of poor sweet potato flakes were found. Similar results were detected when both forms of the beta-carotene fraction were compared with good flakes. A significant difference in the odors of the fifth carotene and poor sweet potato flakes was also observed. The odors of the oxidized carotenoid fractions two, six, seven, eight, and ten were different from the odor of the poor sweet potato flakes in more than 50 per cent of the total judgments. Differences in the odors of the carotenoid fractions four, nine, and eleven and poor sweet potato flakes were detected in 40 per cent or more of the responses.

The results of the olfactory evaluation of good and poor sweet potato flakes in paired tests are presented in Table 5. A difference in the aroma of good and poor sweet potato flakes was indicated by 85 per cent of the total judgments. Of the 85 per cent of responses distinguishing a difference in the aroma of the two samples, 77 per cent identified the aroma of the standard sweet potato flake sample as more desirable.

The ability of panel members to distinguish three samples of sweet potato flakes from poor sweet potato flakes in triangle tests for five replications is presented in Table 6. The panel members were able to distinguish differences in the flavors of the three sweet potato flake samples and poor sweet potato flakes. In a comparison of the flavor of good and poor sweet potato flakes, 90 per cent of the total number of judgments made indicated a difference.

TABLE 4

ABILITY OF PANEL MEMBERS TO DISTINGUISH AROMA OF POOR SWEET POTATO FLAKES FROM OXIDIZED CAROTENOIDS[a]

Position Number	Designated oxidized carotenoids	Per cent of Responses[b]	
		Alike	Different
2	phytofluene	44.44	55.56
3	beta-carotene (pure crystals)	17.78	82.22
3	beta-carotene (supernatant)	24.44	75.56
4	zeta-carotene	53.33	41.67
5	mono-5, 8 beta-carotene epoxide	17.78	82.22
6	"pro-gamma"	48.89	51.11
7	gamma-carotene	48.89	51.11
8	di-5, 8 carotene epoxide	48.89	51.11
9	cis-5, 8 cryptoxanthin	51.11	48.89
10	cis-5, 8 epoxide	46.67	53.33
11	5, 8 cryptoxanthin	60.00	40.00

[a]Per cent of panel members making judgments on paired tests.

[b]Based on 75 judgments.

TABLE 5

ABILITY OF PANEL MEMBERS TO DISTINGUISH AROMA OF GOOD SWEET POTATO FLAKES FROM POOR SWEET POTATO FLAKES AND TO IDENTIFY THE MORE DESIRABLE SAMPLE[a]

	Responses[b]	
	Number	Per cent
Difference detected	64	85.33
Difference detected and more desirable sample identified	58	77.33

[a]Per cent of panel members making judgments on paired tests and identifying the more desirable sample.

[b]Based on 75 judgments.

TABLE 6

ABILITY OF PANEL MEMBERS TO DISTINGUISH THREE SAMPLES OF SWEET POTATO FLAKES FROM POOR SWEET POTATO FLAKES[a]

Sweet potato flake samples compared	Responses[b]	
	Number	Per cent
Good mixed with oxidized beta-carotene with Poor	65	86.67
Good mixed with oxidized non-saponifiable fraction with Poor	66	88.00
Good with Poor	68	90.67

[a]Per cent of panel members making correct judgment on triangle tests.

[b]Based on 75 judgments.

Differences in the flavor of the other two samples of sweet potato flakes were distinguished by the panel members at a slightly lower percentage of the total responses. Panel members distinguished a difference in the flavors of good sweet potato flakes mixed with the oxidized non-saponifiable fraction and poor sweet potatoes in 88 per cent of their responses. Differences in the flavors of good sweet potato flakes mixed with oxidized beta-carotene and poor sweet potatoes were detected by 86 per cent of the total number of responses.

The ability of panel members to recognize off-flavor in comparisons of three samples of sweet potato flakes with poor sweet potato flakes in triangle tests is presented in Table 7. The data represent only the responses of panel members who correctly identified the odd sample in the triangle test for flavor detection and detected the presence of off-flavors in the samples. Panel members correctly identifying the odd sample detected off-flavors in each of the three comparisons of sweet potato flakes with poor sweet potatoes in 87 to 93 per cent of the total number of responses.

Gustatory evaluation of a comparison of three samples of sweet potato flakes with poor sweet potato flakes for identification of off-flavors in triangle tests is shown in Table 8. The data represent only the responses of panel members who correctly identified the odd sample in the triangle test for flavor detection and detected the presence of off-flavors in the samples. A larger percentage of panel members identified the poor sweet potato flakes as the sample possessing the most off-flavor when comparisons of two samples of flakes, good and good mixed with oxidized beta-carotene, were compared with poor flakes.

TABLE 7

ABILITY OF PANEL MEMBERS TO RECOGNIZE OFF-FLAVOR IN COMPARISONS OF THREE SAMPLES OF SWEET POTATO FLAKES WITH POOR SWEET POTATO FLAKES[a]

Sweet potato flake samples compared	Responses[b]	
	Number	Per cent
Good mixed with oxidized beta-carotene with Poor	61	93.85
Good mixed with oxidized non-saponifiable fraction with Poor	58	87.88
Good with Poor	60	88.24

[a]Per cent of panel members making correct judgment on triangle tests and detecting the presence of off-flavor.

[b]Based on number of judgments correctly identifying odd samples.

TABLE 8

ABILITY OF PANEL MEMBERS TO RECOGNIZE AND IDENTIFY OFF-FLAVOR IN COMPARISONS OF THREE SAMPLES OF SWEET POTATO FLAKES WITH POOR SWEET POTATO FLAKES[a]

Test	Sweet potato flake samples possessing off-flavors	Responses[b]	
		Number	Per cent
1	Good Sweet Potato Flakes Mixed With Oxidized Beta-carotene		
	Good mixed with oxidized beta-carotene	3	4.92
	Poor	54	88.52
	Good mixed with oxidized beta-carotene and Poor[c]	4	6.56
2	Good Sweet Potato Flakes Mixed With Oxidized Non-saponifiable Fraction		
	Good mixed with oxidized non-saponifiable fraction	7	12.07
	Poor	35	60.34
	Good mixed with oxidized non-saponifiable fraction and Poor[c]	17	29.31
3	Good Sweet Potato Flakes		
	Good	3	5.00
	Poor	53	88.33
	Good and Poor[c]	4	6.67

[a]Per cent of panel members making correct judgment on triangle tests, detecting the presence of off-flavor, and identifying the off-flavored sample(s).

[b]Based on 75 judgments.

[c]Identified off-flavors in both samples.

In the test of good sweet potato flakes mixed with the oxidized non-saponifiable fraction and poor sweet potatoes, panel members identified the poor sweet potato sample as off-flavored in 60 per cent of the responses. Good sweet potato flakes mixed with oxidized beta-carotene were identified as off-flavored in 4 per cent of the judgments. Good sweet potato flakes mixed with the non-saponifiable fraction were identified as off-flavored by 12 per cent of the responses. Panel members identified both tests of good sweet potatoes and poor sweet potatoes and good sweet potato flakes mixed with oxidized beta-carotene and poor sweet potatoes as off-flavored in 6 per cent of their responses. Both good sweet potato flakes mixed with the oxidized non-saponifiable fraction and poor sweet potatoes were identified as off-flavored by 29 per cent of the judgments.

Panel members were asked to indicate whether the factors aroma, flavor, or aroma and flavor had influenced their judgments in the triangle tests for flavor detection. The factors influencing the decision of panel members in the triangle tests are shown in Table 9. Over 60 per cent of the responses of panel members were influenced by flavor. A combination of the factors aroma and flavor influenced the decision of 30 to 36 per cent of the panel members. Aroma was the factor which least influenced the responses of the panel members in the triangle tests for flavor detection.

TABLE 9

FACTORS INFLUENCING DECISION OF PANEL MEMBERS IN TRIANGLE TESTS

Tests	Factor	Responses[a] Number	Per cent
1	Good Sweet Potato Flakes Mixed with Oxidized Beta-Carotene Compared with Poor Sweet Potato Flakes		
	Aroma	1	1.35
	Flavor	46	62.16
	Aroma and Flavor	27	36.49
2	Good Sweet Potato Flakes Mixed with Oxidized Non-saponifiable Fraction Compared with Poor Sweet Potato Flakes		
	Aroma	1	1.35
	Flavor	50	67.57
	Aroma and Flavor	23	31.08
3	Good Sweet Potato Flakes Compared with Poor Sweet Potato Flakes		
	Aroma	3	4.00
	Flavor	49	65.33
	Aroma and Flavor	23	30.67

[a]Responses in Tests 1 and 2 based on 74 judgments.
Responses in Test 3 based on 75 judgments.

CHAPTER V

GENERAL DISCUSSION

Results of this sensory evaluation of oxidized carotenoids and good sweet potato flakes indicate a difference in the odors of carotenes one, two, and five and good sweet potato flakes. There appeared to be more similarity in the odors of pure crystals of beta-carotene and good sweet potato flakes than in the odors of the supernatant of beta-carotene and good sweet potato flakes. For the remaining oxidized carotenoid fractions four, and six through eleven, the aromas were not distinctively different from the odor of the good sweet potato flakes for the panel members to make a choice.

The odor of the first oxidized carotenoid fraction was conclusively different from the odor of poor sweet potato flakes. The odors of the other fractions of oxidized carotenoids, however, were not distinctive enough for the panel members to make a choice between the odors of these carotenoid fractions and the poor sweet potato flakes. There were more similarities in the odors of the oxidized carotenoid fractions and poor sweet potato flakes than with good sweet potato flakes. Similarity in odors increased between the beta-carotene supernatant and poor sweet potato flakes. The odors of fractions two and five of the oxidized carotenoids were decisively different from the odor of good sweet potato flakes but the panel members could not as readily detect a difference when fractions two and five were paired with the poor sweet potato

flakes. Since panel members could not definitely distinguish the odors of certain carotenoid fractions from poor sweet potato flakes, it appears that perhaps some component of the fractions can be correlated to off-odors and off-flavors. Results from the research of Purcell (5) indicated that compounds associated with the carotenoids could be the primary sources of the off-odors that occur in precooked, dehydrated sweet potato flakes.

From data gathered in further investigation of the oxidized carotenoid fractions and good sweet potato flakes, differences in the odors of both the pure crystals and the supernatant of beta-carotene were found significantly different from the odor of the good sweet potato flakes. The odors of the remaining carotenoid fractions four, and six through eleven were not definitely different from the odor of the good sweet potato flakes.

A conclusive difference in the odors of the pure crystals and the supernatant of beta-carotene and carotene five and poor sweet potato flakes was found. Purcell (5) reported that the odors of pure beta-carotene crystals and of deteriorated sweet potato flakes did not appear to be the same. With the remaining oxidized carotenoid fractions four, and six through eleven the odors were not distinctively different from the odor of the poor sweet potato flakes.

The odors of the oxidized carotenoid fractions one, three, both the pure crystals and the supernatant, and five were different from the odors of both good and poor sweet potato flakes. A difference in the odor of carotene two and good sweet potato flakes was found; but, the panel members were not able to conclusively distinguish a difference in the odor of carotene two and poor sweet

potato flakes. Findings of this investigation did not reveal a definite difference in the odors of the remaining oxidized carotenoid fractions four, and six through eleven and good and poor sweet potato flakes.

The differences obtained in the first and second series of olfactory tests might possibly indicate a change in the composition of head space in the vials containing the oxidized carotenoid fractions. There is also the possibility that these differences could have resulted from over-oxidation of the oxidized carotenoid fractions because of the length of time the covers were removed. The tops of the vials were removed one week prior to evaluation to let a chemical odor detected in preliminary studies escape. During the last series of olfactory tests, covers were put back on the vials to allow the head space to rebuild. Exposure to light may also have increased oxidation of the carotenoid fractions.

Results of the olfactory tests of good and poor sweet potato flakes showed a conclusive difference in the odors of the good and poor flakes. The good sweet potato flakes were identified as having a more desirable aroma than the poor sweet potato flakes. These findings were similar to those observed by others (5, 7) who reported that dehydrated sweet potatoes canned under nitrogen lacked off-odors. Deobald et al. (8) found that dehydrated sweet potatoes canned in air developed off-odors and the results of this study are in agreement with these results.

The findings of the gustatory evaluation revealed a difference in the flavors of three samples of sweet potato flakes and the flavor of poor sweet

potato flakes. In a comparison of poor sweet potato flakes with good sweet potato flakes, good flakes mixed with oxidized beta-carotene, and good flakes mixed with the oxidized non-saponifiable fraction, all three samples could be distinguished from the poor samples of sweet potato flakes. There was little similarity between the flavors of poor sweet potato flakes and good sweet potato flakes and sweet potato flakes mixed with oxidized beta-carotene. The data, however, showed that the flavor of the good sweet potato flakes mixed with the oxidized non-saponifiable fraction were not as distinctively different from the flavor of the poor sweet potato flakes as were the good flakes and the good flakes mixed with oxidized beta-carotene. These findings infer that some component of the non-saponifiable fraction may possibly be associated with the off-odors and off-flavors of precooked, dehydrated sweet potato products. The non-saponifiable fraction contains all of the eleven carotenoid pigments. Off-flavors were readily detected in the poor sweet potato samples. The detection of off-flavors in the poor samples of sweet potato flakes was similar to the results observed by Lambou (9).

Flavor influenced the decision of the panel members in gustatory evaluation more than aroma. A combination of these factors did influence some of the judgments.

The results of this investigation indicate that there is a difference in the odors and flavors of good and poor samples of precooked, dehydrated sweet potato flakes and beta-carotene. In spite of the fact that more than 90 per cent of the carotenoid content of sweet potatoes is beta-carotene, it appears that

beta-carotene is not the precursor of the off-odor and off-flavor that develops in precooked, dehydrated sweet potato flakes. In contrast, several researchers (7, 10, 12) have correlated the loss of beta-carotene and the development of off-odors and off-flavors in dehydrated sweet potato products. Under the conditions of this study, the cause of the off-odor and off-flavor in precooked, dehydrated sweet potato flakes might be related to the non-saponifiable fraction of the carotenoids.

Precooked, dehydrated sweet potato flakes canned in air were off-odored and off-flavored. Those sweet potato flakes canned in nitrogen were not off-odored or off-flavored. These findings substantiate the results observed by several researchers (6, 7, 8).

CHAPTER VI

SUMMARY AND RECOMMENDATIONS

Summary

Paired tests for odor detection and triangle tests for flavor detection were used for the sensory evaluation of oxidized carotenoids and precooked, dehydrated sweet potato flakes. This investigation was conducted to determine if beta-carotene or any of the oxidized carotenoid fractions extracted from sweet potatoes are the precursors of off-odors and off-flavors in precooked, dehydrated sweet potato flakes. An experiment was conducted to determine if there is a difference in the odors and flavors of standard and deteriorated precooked, dehydrated sweet potato flakes. The responses of fifteen panel members to the odors and flavors of the samples were recorded on scorecards.

For olfactory evaluation a paired test was used to determine if the odors of oxidized carotenoid fractions and good and poor sweet potato flakes were alike, related, or different. Further testing was conducted to determine if the odors of the oxidized carotenoid fractions and good and poor sweet potato flakes could be defined as alike or different. Triangle tests were used for gustatory evaluation to determine if there is a difference in the flavor of good sweet potato flakes, good flakes mixed with oxidized beta-carotene, and good flakes mixed with the oxidized non-saponifiable fraction when compared with poor sweet potato flakes.

Results of this study indicate that there is a conclusive difference in the odors of the oxidized carotenoid fractions one, three, and five and good and poor sweet potato flakes. There is also a difference in the odors of the second carotenoid fraction and good sweet potato flakes; however, the difference in the odor of fraction two and poor sweet potato flakes was not as pronounced as was the difference in the odor of fraction two and good sweet potato flakes. With the remaining oxidized carotenoid fractions four, and six through eleven similarities in the odors of these fractions and good and poor sweet potato flakes were found.

The odor and flavor of sweet potato flakes canned in air were different from the odor and flavor of sweet potato flakes canned in nitrogen. The sweet potato flakes canned in air were identified as having off-odors and off-flavors. The sweet potato flake sample canned in nitrogen was identified as the more desirable sample of sweet potato flakes.

The good sweet potato flakes and the good flakes mixed with oxidized beta-carotene were different from the poor sweet potato flakes in both aroma and flavor. Off-odors and off-flavors were identified in the poor sweet potato flakes. The results of this study also showed that there was not a conclusive difference in the flavor of poor sweet potato flakes and good sweet potato flakes mixed with the oxidized non-saponifiable fraction.

Under the conditions of this study it appears that beta-carotene is not the precursor of the off-odor and off-flavor of precooked, dehydrated sweet potato flakes. However, there is an indication that the off-odor and off-flavor

could be associated with some of the oxidized carotenoid fractions or the non-saponifiable fraction.

Recommendations for Additional Investigations

Although the results of this investigation support the hypothesis that beta-carotene is not the precursor of the off-odors and off-flavors in precooked, dehydrated sweet potato flakes, more extensive sensory evaluation of these products is needed. Individuals vary in their ability to recognize and detect odors and flavors in foods, and human variability could be a source of experimental error. Further sensory evaluations would strengthen the results obtained in this study.

Panel members had difficulty in detecting odors in some of the oxidized carotenoid fractions. More control of the oxidized carotenoid fractions would be desirable in further studies. Entrapping the oxidized carotenoid fractions in larger bottles or vials would create a larger head space and possibly facilitate the ease and accuracy of odor detection for panel members. Opening the vials for extended periods of time resulted in a decrease in the intensity of the odors. Supplying fresh samples of oxidized carotenoids and several bottles of each fraction each week of the evaluation period would permit less frequent use of the same sample and allow time for the head space to rebuild in the closed container before further evaluation.

When smelling sweet potato flake samples in the cans or in larger containers, the odors were more easily detected. Presenting larger samples of

sweet potato flakes in larger containers would concentrate the odor and increase the ability of the panel members to detect odors in the sweet potato flake samples.

A closer control of texture differences in sweet potato flake samples would be desirable. Grinding each sample of sweet potato flakes with a mortar and pestle daily before presentation to be evaluated would eliminate differences in texture and might increase the intensity of the odor of the samples because of the increased surface area of the products. Texture differences of the reconstituted sweet potato flakes could be reduced by whipping the samples for a longer period of time in a blender.

The use of test booths for individual evaluation might serve to strengthen the results obtained through sensory evaluation by creating an atmosphere more conducive to concentration. A completely darkened room with red lighting as the only source of light would serve to further reduce color bias of the samples.

Panel members detected a chemical odor in the oxidized carotenoid fractions which they believe masked the odors of the samples. Eliminating the chemical odor detected in the oxidized carotenoid fractions would be an improvement. Drying the carotenoid fractions in a dessicator rather than a rotary-film evaporator might help to reduce this chemical odor.

Sensory comparisons of dehydrated sweet potatoes, carrots and Irish potatoes would establish whether or not there is a relationship among the odors of the different commodities. A significant difference in the odor of oxidized carrots and oxidized sweet potatoes would indicate involvement of compounds

other than carotenes since the major component is the same in each product. If the odors of oxidized carrots and sweet potatoes are similar to oxidized Irish potatoes, it may be concluded that carotenes are not involved since Irish potatoes have an insignificant amount of carotenes.

Analysis of flavor components of the products by gas phase chromatography could serve an important function. Comparisons of chromatographed flavor components and sensory evaluations may help to identify existing off-odors and off-flavors.

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APPENDIX I

SCORECARDS, QUESTIONNAIRE, AND INFORMATION SHEET

SCORECARDS FOR ODOR DETECTION

NAME_____

DATE_____

PAIRED TEST FOR ODOR DETECTION

1. Circle one word below which describes the relationship of the odor of the two samples.

ALIKE RELATED DIFFERENT

NAME_____

DATE_____

PAIRED TEST FOR ODOR DETECTION

1. Is there a difference in the odor of the two samples?

Yes_____ No_____

2. If the answer to part one is yes, circle the letter of the samples you consider more desirable.

_____ _____

NAME_____

DATE_____

PAIRED TEST FOR ODOR DETECTION

1. Circle one word below which describes the relationship of the odor of the two samples.

ALIKE DIFFERENT

SCORECARD FOR FLAVOR DETECTION

NAME_____

DATE_____

TRIANGLE TEST FOR FLAVOR DETECTION

1. Two of the samples are identical in flavor and one sample is different. Circle the letter of the odd sample.

_____ _____ _____

2. Circle the factor or factors which influenced your decision.

AROMA FLAVOR AROMA AND FLAVOR

3. Can you detect an off-flavor in any of the samples?

Yes_____ No_____

4. If so, circle the letter or letters of the sample or samples, in which you detect the off-flavor.

_____ _____ _____

PERSONAL DATA

Name: _____

Address: _____

Phone Number: _____

Age: _____ Sex: _____

Occupation: _____

Department or Major: _____

Experience in Test Panels: _____

_____

_____

Health: Good _____ Fair _____ Poor _____

Do you smoke? Yes _____ No _____

Do you like sweet potatoes? Exceedingly well _____

Moderately well _____ Fairly well _____

Any sessions you know of now that you will have to miss?

(give dates) _____

_____

INSTRUCTIONS FOR JUDGES AT EVALUATION SESSIONS

1. Smell or taste a sample only once. Rely on first sensations in evaluating each sample.

2. Pause a few seconds before smelling or tasting each sample.

3. When tasting, take enough of the sample to taste. Hold sample in mouth a few seconds before swallowing.

4. Scorecards are present on each tray for each test. Pick up one. Write your name and the date on it; complete it and turn the scorecard face down on the tray underneath the piece of construction paper.

5. Be sure to complete all parts of the scorecard.

6. In judging each test, work from left to right with each tray.

7. When tasting, rinse mouth with water between each sample. Make sure mouth is free from last sample before tasting new one.

8. If you smoke, please refrain from smoking shortly before your evaluation session.

9. Please do not talk or make any unnecessary facial expressions during the evaluation session.

10. If you become fatigued, wait a minute or two before continuing. You will recognize fatigue as the sensation when all samples smell or taste alike.

APPENDIX II

ODOR DETECTION DATA OF GOOD AND POOR SWEET POTATO FLAKES AND OXIDIZED CAROTENOIDS

TABLE 1

ODOR DETECTION DATA OF GOOD SWEET POTATO FLAKES AND OXIDIZED CAROTENOIDS[a]

Position Number	Designated oxidized carotenoids	Responses[b]					
		Alike		Related		Different	
		Number	Per cent	Number	Per cent	Number	Per cent
1	phytoene	0	0	1	1.22	74	98.67
2	phytofluene	3	4.00	12	16.00	60	80.00
3	beta-carotene (pure crystals)	10	13.33	29	38.67	36	48.00
3	beta-carotene (supernatant)	5	6.67	11	14.67	59	78.67
4	zeta-carotene	14	18.67	21	28.00	40	53.33
5	mono-5, 8 beta-carotene epoxide	5	6.67	10	13.33	60	80.00
6	"pro-gamma"	10	13.33	25	33.33	40	53.33
7	gamma-carotene	14	18.67	27	36.00	34	45.33
8	di-5, 8 carotene epoxide	15	20.00	32	42.67	28	37.33
9	cis-5, 8 cryptoxanthin	22	29.33	29	38.67	24	32.00
10	cis-5, 8 epoxide	24[c]	32.43	27[c]	36.49	23[c]	31.08
11	5, 8 cryptoxanthin	22	29.33	30	40.00	23	30.67

[a]Judgments of panel members in paired tests.

[b]Based on 75 judgments unless otherwise indicated.

[c]Based on 74 judgments.

TABLE 2

ODOR DETECTION DATA OF POOR SWEET POTATO FLAKES AND OXIDIZED CAROTENOIDS[a]

Position Number	Designated oxidized carotenoids	Responses[b]					
		Alike		Related		Different	
		Number	Per cent	Number	Per cent	Number	Per cent
1	phytoene	1	1.33	6	8.00	68	90.67
2	phytofluene	22	29.33	20	26.67	33	44.00
3	beta-carotene (pure crystals)	5	6.67	25	33.33	45	60.00
3	beta-carotene (supernatant)	20	26.67	22	29.33	33	44.00
4	zeta-carotene	15	20.00	27	36.00	33	44.00
5	mono-5, 8 beta-carotene epoxide	18	24.00	15	20.00	42	56.00
6	"pro-gamma"	8	10.67	26	34.67	41	54.67
7	gamma-carotene	16	21.33	31	41.33	28	37.33
8	di-5, 8 carotene epoxide	14	18.67	30	40.00	31	41.33
9	cis-5, 8 cryptoxanthin	12	16.00	25	33.33	38	50.67
10	cis-5, 8 epoxide	14[c]	18.92	32[c]	43.24	28[c]	37.84
11	5, 8 cryptoxanthin	14[c]	18.92	33[c]	44.59	27[c]	36.49

[a]Judgments of panel members on paired tests.

[b]Based on 75 judgments unless otherwise indicated.

[c]Based on 74 judgments.

TABLE 3

ODOR DETECTION DATA OF GOOD SWEET POTATO FLAKES AND OXIDIZED CAROTENOIDS[a]

Position Number	Designated oxidized carotenoids	Responses[b]			
		Alike		Different	
		Number	Per cent	Number	Per cent
3	beta-carotene (pure crystals)	7	15.56	38	84.44
3	beta-carotene (supernatant)	5	11.11	40	88.89
4	zeta-carotene	19	42.22	26	57.78
6	"pro-gamma"	16	35.56	29	64.44
7	gamma-carotene	22	48.89	23	51.11
8	di-5, 8 carotene epoxide	19	42.22	26	57.78
9	cis-5, 8 cryptoxanthin	13	28.89	32	71.11
10	cis-5, 8 epoxide	24	53.33	21	46.67
11	5, 8 cryptoxanthin	16	35.56	29	64.44

[a]Judgments of panel members on paired tests.

[b]Based on 45 judgments.

TABLE 4

ODOR DETECTION DATA OF POOR SWEET POTATO FLAKES AND OXIDIZED CAROTENOIDS[a]

Position Number	Designated oxidized carotenoids	Responses[b]			
		Alike		Different	
		Number	Per cent	Number	Per cent
2	phytofluene	20	44.44	25	55.56
3	beta-carotene (pure crystals)	8	17.78	37	82.22
3	beta-carotene (supernatant)	11	24.44	34	75.56
4	zeta-carotene	24	53.33	21	46.67
5	mono-5, 8 beta-carotene epoxide	8	17.78	37	82.22
6	"pro-gamma"	22	48.89	23	51.11
7	gamma-carotene	22	48.89	23	51.11
8	di-5, 8 carotene epoxide	22	48.89	23	51.11
9	cis-5, 8 cryptoxanthin	23	51.11	22	48.89
10	cis-5, 8 epoxide	21	46.67	24	53.33
11	5, 8 cryptoxanthin	27	60.00	18	40.00

[a]Judgments of panel members on paired tests.

[b]Based on 45 judgments.